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EVALUATION OF THE LINDE FLOW WARNING DEVICE,(U)
DEC 65 J V HARTER
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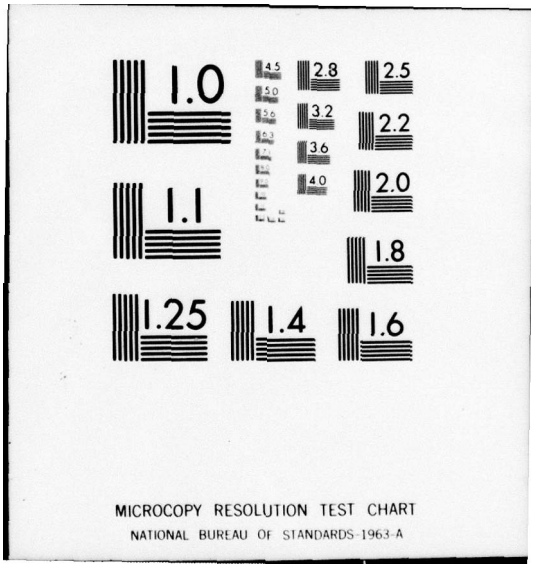
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NAVY EXPERIMENTAL DIVING UNIT

U.S. NAVY EXPERIMENTAL DIVING UNIT
WASHINGTON NAVY YARD

WASHINGTON, D.C. 20390

(14) NEDU-Evaluation-8-65

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EVALUATION REPORT 8-65

EVALUATION OF THE LINDE FLOW WARNING DEVICE

BUREAU OF SHIPS
PROJECT F011-06-03 TASK 3380

BY

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ABSTRACT

A flow warning device designed to provide a visible indication to the diver when the mass flow of gas to his breathing circuit varied, was evaluated for proper operation and reliability. The basic design of the device is considered feasible, however, continual failures of the sensing element caused the specific apparatus to be unsuitable for use by a diver.

SUMMARY

PROBLEM

1. Is the Linde Company Flow Warning Device suitable to provide the underwater swimmer, using mixed-gas SCUBA, with an indicator of interrrupted or variation of flow of the supply gas?

FINDINGS

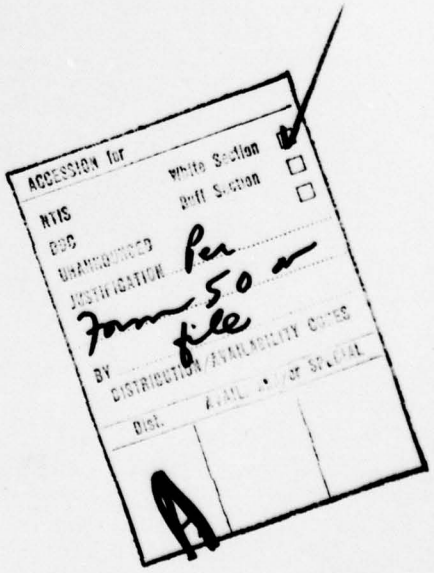
1. The Linde Flow Warning Device is not suitable for use as an indicator of interrupted flow in semi-closed circuit mixed-gas diving apparatus.

2. The Linde Flow Warning Device was unable to function for a length of time sufficient to permit placing it in water or under pressure.

3. The Linde Flow Warning Device was designed for use with the MK V mixed-gas SCUBA. This apparatus is no longer in use by the U.S. Navy.

RECOMMENDATION

It is recommended that no additional effort be expended on development of this equipment.



ADMINISTRATIVE INFORMATION

Reference: Bureau of Ships Contract NObs 76708

The equipment tested was provided in accordance with the above reference. The equipment was originally received in the summer of 1959. This report has been written in order to gather the remaining data together and provide a record of this project termination. Because of the length of time involved in the evaluation and the almost total lack of recorded test data, little technical information was available for this report. The project was terminated without further tests due to the failure of the device, the expense of repair, and the fulfillment of the basic requirement through other means.

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1. INTRODUCTION

1.1 Background

1.1.1 The use of semi-closed circuit mixed-gas underwater breathing apparatus requires that a predetermined, minimum mass flow of the gas mixture be continuously injected into the breathing circuit. If the mass flow of gas into the breathing circuit is reduced without the diver's knowledge, anoxia and unconsciousness will result without warning. If the mass flow of gas into the breathing circuit is increased above the preset mass flow rate, the gas supply may be exhausted sooner than the planned duration of the dive.

1.1.2 A means of indicating changes in the mass flow rate would greatly reduce the seriousness of any change in the flow from its required setting. If the diver is aware of a low flow of gas he will be able to supplement his gas supply by use of the bypass valve until he reaches the surface.

1.1.3 The Linde Co. of Belleville, N. J. was contracted by the Bureau of Ships to design, develop, and manufacture a constant flow regulator, control block and warning device compatible with the U.S. Navy Mark V mixed gas SCUBA. The warning device was designed to give a separate indication when the flow becomes more than $\pm$ 10 percent from the preset valve.

1.2 Objective

1.2.1 The objective of this evaluation was determination of the suitability of the Linde Flow Warning Device for use as a component of a self-contained, semi-closed circuit underwater breathing apparatus.

1.3 Scope

1.3.1 The scope of this evaluation was limited to set up and operation of one flow warning device provided by the Linde Company. All tests were conducted under atmospheric pressure.

2. DESCRIPTION

2.1 The warning device is schematically illustrated in figure 1. Photographs are provided in figures 2, 3, 4 and 5. The flow warning device consists of a differential control valve, a flow control valve, a check valve, an aneroid sensing device, a battery pack and red and white warning lights.

2.2 The warning device is designed to operate with a 20 psi differential pressure across the sensing element. This differential pressure is set through adjustment of the differential control valve for each flow rate setting. A variation in the preset flow rate of $\pm$ 10 percent will also cause a variation of $\pm$ 10 percent in the differential. This variation is sensed by the aneroid sensing device which activates a switch that closes the circuit between the battery supply and either the red or white light. Two mercury cells, packed in the water-tight switch case, provide the power required to operate the indicator lamps.

3. OPERATION

3.1 Start

1. Connect gauge at fitting (G) and flowmeter at fitting (F).

2. Close valve (1) to divert flow from diver to flowmeter.

3. Close valve (2) by turning clockwise to restrict the flow of gas.

4. Open control valve (3) by turning counterclockwise to prevent excessive differential pressure across sensing element.

5. Open cylinder valve on SCUBA rig slowly until entire system is brought up to operating pressure.

6. Adjust flow control valve (2) until desired flow rate is read on flowmeter.

7. Adjust differential control valve (3) by turning clockwise until low flow (white) light goes "off" and note pressure on gauge at (G). Continue to adjust clockwise until high flow (red) light goes "on" and again note pressure on gauge at (G). Readjust valve counterclockwise to a point midway between these two pressure readings. Check flow readings on flowmeter. Minor readjustment of flow control valve (2) may be necessary to give exact flow rate required. Both indicator lamps should be "off" and the unit is ready for operation.

8. To check the operation of the indicator, adjust the control valve (2) clockwise until a flow rate decrease or 5 to 10 per cent from the original setting is achieved on the flowmeter. The low flow (white) indicator lamp should be "on". Then adjust control valve (2) counterclockwise until a flow rate increase of 5 to 10 percent from the original setting is achieved on the flowmeter. The high flow (red) indicator lamp should be "on". In each case, the indicator lamp should remain "off" until the variation exceeds 5 per cent but should come "on" on or before the variation reaches 10 percent.

3.2 To Stop

1. Open differential control valve (3) by turning counterclockwise to reduce differential across sensing device.

2. Turn cylinder valve on SCUBA rig "off" and allow system to bleed down.

4. PROCEDURE

4.1 The test procedure utilized during this evaluation consisted of adjustment of the device on the MK V semi-closed circuit SCUBA apparatus in accordance with the operation procedures described in 3 above. The operation of the device was tested by varing the flow control valve (2) until a flow rate of 10 percent from the original setting was achieved on the flow meter.

5. RESULTS

5.1 Results of tests dated 27 October 1959 recorded by LTJG G. M. JANNEY, USNR.

5.1.1 The regulator and flow warning device were connected to a source of high pressure helium-oxygen mixture (80%He). The pressure on the regulator was set at approximately 100 psi and a flow of 9 lpm was set using the flow setting needle valve. The warning device was set halfway between the two positions at which the lights came on. By increasing or decreasing the flow, using the flow setting needle valve, the warning device was made to operate. A range of approximately 1.5 lpm was observed where both lights remained off.

5.1.2 After 20 to 30 minutes of operation, the warning device ceased to operate. Neither light would come on under any condition. The flow warning device was partially disassembled in an attempt to determine the cause of the failure. It was not possible to disassemble the pressure switch or to determine the cause of failure. The warning device was reassembled.

5.1.3 During the operation it was observed that either the flow setting needle valve or the warning device setting needle valve could be used to shut off the flow completely. It is likely that shutting the warning device needle valve was the cause of the failure, since this would result in a differential of the entire reduced pressure across the switch.

5.1.4 It was also noted that the regulator pressure (reduced) varied strongly with a change in the flow setting. With no flow the reduced pressure was set at 270 psi. When the flow was set at approximately 18 lpm, the pressure decreased to 70 psi.

5.1.5 When the regulator and warning device were being placed in the packing box, one of the lights came on intermittently. Examination of the light bulb assembly revealed that the connections at the light sockets were not soldered and intermittent contact was being made. However, the pressure switch still appeared to be damaged, since the high flow indicator light was on when no flow existed.

5.2 The warning device was returned to the Linde Co. for inspection and repair. It was found that the aneroid had been collapsed due to the shutting of the adjusting valve and resultant increased pressure differential. The aneroid was replaced and the check valve shown in figure one was placed in the circuitry. This valve was designed to open when the pressure differential reached 28-30 psi, to prevent damage to the aneroid due to closing of the differential control valve.

5.3 The device was returned to NAVXDIVINGU sometime in 1960. A failure resulted after a short period of test. Unfortunately the test procedure and results were not recorded, so the cause of this failure is unknown. The device was again returned to the manufacturer for repairs. It is believed that the device was returned to NAVXDIVINGU sometime in 1962. At this time it was noted that the aneroid switch compartment leaked gas when pressure was applied, and the device did not operate properly.

5.4 A fully repaired flow warning device was received at NAVXDIVINGU in September 1964. Test and evaluation of the repaired device commenced on 29 September 1964 after thoroughly briefing the project engineer of the previous operating difficulties and failures. The MK V apparatus was charged to 2200 psi with 30% O_2 70% He. Batteries were installed in the sensing cell and a white light indicating a high flow came on. No pressure was being applied to the unit at this time. 282 psi was set on the regulator after following the procedures outlined in 3 above. The white light went out before any adjustments could be made. Attempts to get either light to come on through adjustment of the differential control valve failed. The sensing cell was disconnected for examination and it was noted that gas had leaked up the insulation of the electrical wiring to the indicator lights.

5.5 The device was again returned to the manufacturer for a cost estimate to repair. The decision to terminate the project was made upon receipt of the estimate and in light of the MK V having been replaced by the MK VI semi-closed apparatus, and the unreliability of the flow warning device.

6. DISCUSSION

The basic design of the apparatus appeared to be technically feasible as shown on drawings and explained in the operation memorandums supplied by the manufacturer. The differential pressure device afforded a simple means of causing an actuation of a pressure switch. The sensing device used in the apparatus proved to be too delicate for the operation to be performed as evidenced by a total operation time of probably not more than one hour over a five year period. The initial failure in October 1959 was apparently due to securing the differential control valve. This led to the installation of a relief valve by the manufacturer. When the device was assembled in September 1964 the proper direction of flow through this valve was verified prior to pressurization. The unreliability noted in the device should be attributed to poor selection of components and not to the basic design approach.

7. CONCLUSIONS

The Linde flow warning device is not suitable for use as a visable indicator of variable or interrupted flow of gas to the breathing circuit of a diver's breathing apparatus.

8. RECOMMENDATIONS

8.1 It is recommended that no further funds or effort be expended on this project due to the present inability of the device to reliably perform, and due to the lack of requirement for this device at this time.

8.2 It is recommended that if a future requirement should call for a visible light or sound warning system to indicate interrupted flow, the basic design approach included in this device be reevaluated following replacement with more suitable components.

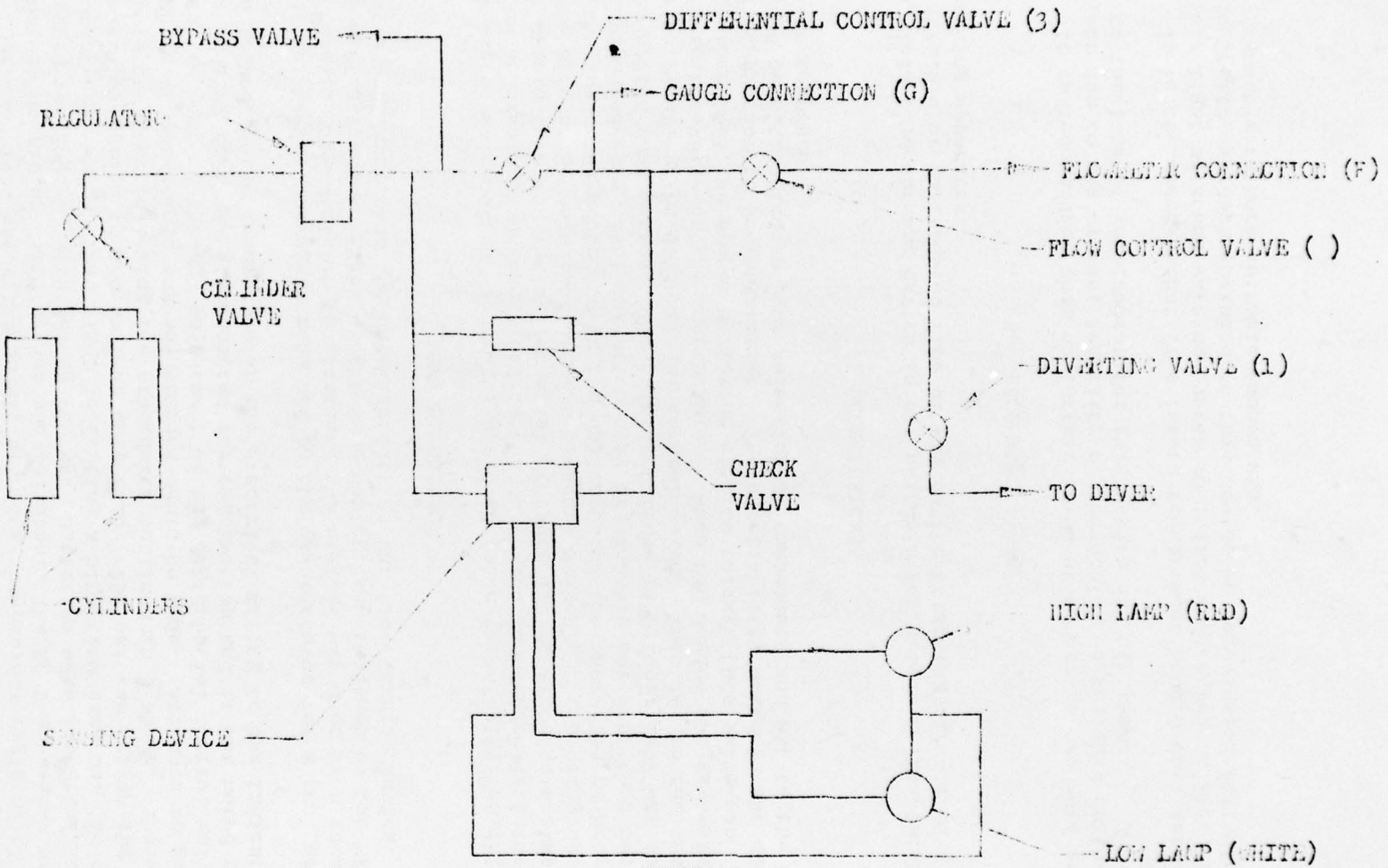

FIGURE 1.

SCHEMATIC DIAGRAM : REGULATOR & WARNING DEVICE